EXPRESS MAIL NO.: EV 008 269 836 US

STRETCHABLE NONWOVEN MATERIALS WITH CONTROLLED RETRACTION FORCE AND METHODS OF MAKING SAME

This application is one of two applications directed to related subject matter filed on the same day. The other application is entitled "MULTIPLE IMPACT DEVICE AND METHOD FOR TREATING FLEXIBLE WEBS" with inventors Robert James Gerndt, Jose Enrique Maldonado, Ann Louise McCormack, and Michael Tod Morman (Express Mail No. EU 838 797 095 US; Attorney Docket No. 19078 PCT) incorporated herein by reference in its entirety.

Field of the Invention

This application claims priority from U.S. Provisional Application No. 60/407,172 filed on August 30, 2002, which is incorporated by reference herein in its entirety.

The present invention relates to nonwoven materials for use in disposable personal care products. More particularly, the present invention relates to stretchable nonwoven materials for use in such products and methods of making the same.

Background of the Invention

There are numerous methods known to those skilled in the art for spinning fibers that can be used to form nonwoven webs. Many of such nonwoven webs are useful in disposable consumer products, such as disposable absorbent articles for absorbing body fluids. For example, such webs can be utilized in the body side covers, facings, liners, or side panels of consumer personal care products, such as in diapers or training pants. Traditionally, inelastic and non-stretchable nonwoven materials have been used for these purposes. It would be desirable, however, for these materials to be highly stretchable or elongatable for certain product applications. For instance, in certain applications it would be desirable for these

materials to stretch by as much as 30 to 150% in the cross machine direction during use, or in both the cross machine and machine directions, and also to demonstrate good recovery (that is the ability to retract upon removal of a biasing force). When such materials are used as part of laminates, the extension load at early stages of the elongation should be low, but the load should become high enough for the consumer to begin to feel "stretch-to-stop" (where a user begins to notice resistance) at the later stages of the useful elongation during use. Certain minimum retraction force is also desirable in order to ensure acceptable and timely recovery.

Numerous attempts have been made to spin thermoplastic elastomers and form spunbond material to this end, but only with limited success. The low melt strength of typical thermoplastic elastomers may cause spinline (fiber) breakage at a fiber size useful in these applications, and at a commercially viable high speed. Alternatively, such spun fibers, if not broken, may be so tacky as to risk becoming roped together, ultimately yielding unacceptable web formation. Even if such material were to be produced at a non- commercially viable speed and at a heavy basis weight, it is likely that the materials would demonstrate an unacceptable rubbery hand or feel, and extension and retraction characteristics that would not satisfy the above mentioned preferences. It should be noted that the elastic response of such fibers to stretching and/or drawing (in the case of inelastic components) also may contribute to insurmountable spinning issues during fiber formation.

While weak molten elastomer spinlines with a high melt strength thermoplastic polymers have been demonstrated in certain bicomponent fiber configurations, these fibers often require additional processing steps. Even if such bicomponent materials are produced, it is often difficult to obtain uniformly distributed sheath/core bicomponent fibers with exceedingly large amounts of elastomeric material in the core portion of the fiber. Attempts to produce such materials often result in sheath/core bicomponent materials in which the sheath structure is non-uniform, thereby allowing the elastomeric core to be exposed in some surface locations along the fiber length. This exposure of elastomeric material allows the generally tacky material to be on the outside of the fibers, and often results in erratic sticking or roping of the fibers, as previously described.

Manufacturers of personal care products are always looking for new materials and ways of constructing such products in order to make them more functional for the application that they desire to accomplish, or alternatively more efficient in their manufacture or operation. For example, there is a need for meltspun materials that can be produced using simplified manufacturing processes, and which demonstrate predictable elastic performance. Further,

there is a need for methods of manufacturing such meltspun webs so as to control the hand or feel of the final web that is incorporated into the consumer personal care product. In particular, it has been problematic for elastic webs to overcome their "sticky feel", when they are employed in consumer products, since traditional elastomeric materials often include tackifiers and therefore are sticky to the touch. Finally, there is a need for manufacturing processes that allow for the control of the retraction capability of an elastic web, and for the production of highly crimped elastic fibers, elastic fibers of various cross-sectional shapes, elastic multicomponent fibers such as side by side bicomponent fibers and sheath/core bicomponent fibers having high percentages of core components, with more uniform coverage of thin sheath components. It is to such needs that the present invention is directed.

Summary of the Invention

A method of forming fibers into a web includes the steps of co-extruding a first elastomeric component and a second thermoplastic component; directing the first and second components through a fiber spin pack to form a plurality of continuous molten multicomponent fibers in spinlines, wherein the first elastomeric component is present in an amount greater than about 70 percent by weight of the molten fibers and the second thermoplastic component is present in an amount of between about 10 and 30 percent by weight of the molten fibers; attenuating the spinlines and routing the plurality of molten fibers through a quench chamber to form a plurality of cooled fibers; routing the plurality of cooled fibers through a fiber draw unit, whereby the fibers are pulled downward; allowing the pulled fibers to be deposited onto a forming surface thereby forming a web wherein the fibers are relaxed; stabilizing the web; bonding the web to produce a web demonstrating greater than about 25 percent machine direction stretch recovery.

These and other features and advantages of the present invention will become apparent after a review of the following detailed description of the disclosed embodiments and the appended claims.

Brief Description of the Drawings

FIG. 1 illustrates a schematic showing a method for forming continuous, bicomponent fibers into a web without the necessity of a post drawing stretch step, which web, exhibits stretch and recovery.

FIG. 2 illustrates various cross sections, in Figures 2A through 2G of bicomponent fibers of the invention.

FIG. 3A-3F are photomicrographs of fibrous webs made in accordance with the invention. Figures 3A-3B specifically illustrate fibrous webs with either smooth or rough surface topographies. Figure 3C and 3D illustrate fibrous webs with highly crimped fibers, and Figures 3E and 3F illustrate views of webs in accordance with this invention which are used to conduct "fiber length per field width" measurements (fiber length per bond spacing) as described below.

FIG. 4A and 4B illustrate an alternative embodiment of the inventive process of Figure 1 in which a formed fibrous web is stretched by a main roller and satellite rolls following formation, depending on the elastomeric components utilized, in order to provide improved elastic attributes.

FIG. 5 illustrates an alternative embodiment of the inventive process of Figure 1 in which a formed fibrous web is stretched by a series of side- by -side rolls following formation.

FIG. 6 illustrates an alternative embodiment of the inventive process of Fig. 1 in which a fibrous web is stretched between belts following web formation.

FIG. 7-19 illustrate through graphical representation, elastic performance of webs made with such elastic materials.

FIG. 20 illustrates data from web characterization utilizing "fiber length per field width" as described further below.

Detailed Description of the Invention

Definitions:

Within the context of this specification, each term or phrase below will include the following meaning or meanings.

An "article" or "product" refers to a garment or other end-use article of manufacture, including but not limited to, diapers, training pants, swim wear, catamenial products, medical garments or wraps, and the like.

The term "bonded" or "bonding" refers to the joining, adhering, connecting, attaching, or the like, of two elements. Two elements will be considered to be bonded together when they are bonded directly to one another or indirectly to one another, such as when each is directly bonded to intermediate elements.

As used herein "point bonding" means bonding one or more layers of fabric, or film at a plurality of discrete bond points. For example, thermal point bonding generally involves passing one or more layers to be bonded between heated rolls such as, for example an engraved pattern roll and a smooth calender roll. The engraved roll is patterned in some way so that the entire fabric is not bonded over its entire surface, and the anvil roll is usually flat. As a result, various patterns for engraved rolls have been developed for functional as well as aesthetic reasons. One example of a point bond pattern is the Hansen Pennings or "H&P" pattern with about a 30 percent bond area when new and with about 200 bonds/square inch as taught in U.S. Patent 3,855,046 to Hansen and Pennings, incorporated by reference herein in its entirety. The H&P pattern has square point or pin bonding areas wherein each pin has a side dimension of 0.038 inches (0.965 mm), a spacing of 0.070 inches (1.778 mm) between pins, and a depth of bonding of 0.023 inches (0.584 mm). Another typical point bonding pattern is the expanded Hansen Pennings or "EHP" bond pattern which produces a 15 percent bond area when new with a square pin having a side dimension of 0.037 inches (0.94 mm), a pin spacing of 0.097 inches (2.464 mm) and a depth of 0.039 inches (0.991 mm). Another typical point bonding pattern designated "714" has square pin bonding areas wherein each pin has a side dimension of 0.023 inches, a spacing of 0.062 inches (1.575 mm) between pins, and a depth of bonding of 0.033 inches (0.838 mm). The resulting pattern has a bonded area of about 15 percent when new. Yet another common pattern is the C-Star pattern which has, when new, a bond area of about 16.9 percent. The C-Star pattern has a cross-directional bar or "corduroy" design interrupted by shooting stars. Other common patterns include a diamond pattern with

repeating and slightly offset diamonds with about a 16 percent bond area and a wire weave pattern looking as the name suggests, e.g. like a window screen, with about a 15 percent bond area. A further pattern is the "s-weave" pattern having about a 17 percent bond area when new and a baby objects pattern having about a 12 percent bond area when new. A further pattern still, is the Ramisch pattern which produces an 8 % bond area when new with a square pin having a side dimension of 0.039 inches (0.991 mm) in a staggered array, a pin spacing of about 0.139 inches (3.53 mm) and a depth of 0.052 inches (1.321 mm).

Such bonding patterns are further described in U.S. Patent No. 5,599,420 to Yeo et al., incorporated by reference herein in its entirety. Typically, the percent bonding area is less than about 50 percent and more desirably varies from around 8 percent to around 30 percent of the area of the fabric laminate web.

The term "laminate" means one or more layers that have been bonded together.

The term "flexible polyolefin" (FPO) refers to polyolefin materials containing propylene based polymer with controlled regions of atactic polypropylene units to achieve a desired crystallinity such as described in U.S. Patent No. 5,910,136 entitled "Oriented Polymeric Microporous Films with Flexible Polyolefins and Methods of Making the Same" to Hetzler and Jacobs; the entire contents of which are incorporated herein by reference. Further description of flexible polyolefins can be found in U.S. Patent No. 5,723,546 to Sustic and assigned to the Rexene Corporation.

The term "spinline" shall refer to the fiber extruded from a spinplate in a meltspinning operation. Alternatively, depending on the context of the phrase within a sentence, the term "spinline" may be used generally to describe the fiber forming process or apparatus used to generally produce fibers.

The term "disposable" refers to articles which are designed to be discarded after a limited use rather than being laundered or otherwise restored for reuse.

The term "fabric" is used to refer to all of the nonwoven fibrous webs described herein.

A "film" refers to a thermoplastic film made using a film extrusion and/or foaming process, such as a cast film or blown film extrusion process. The term includes apertured films, slit films, and other porous films which constitute liquid transfer films, as well as films which do not transfer liquid.

As used herein, the term "bicomponent fibers" refers to fibers which have been formed from at least two polymer sources extruded from separate extruders but spun

together to form one fiber. Bicomponent fibers are also sometimes referred to as conjugate fibers or multicomponent fibers. The polymers are arranged in substantially constantly positioned distinct zones across the cross-sections of the bicomponent fibers and extend continuously along the length of the bicomponent fibers. The configuration of such a bicomponent fiber may be, for example, a sheath/core arrangement wherein one polymer is surrounded by another, or may be a side-by-side arrangement, a pie arrangement, or an "islands-in-the-sea" arrangement. Bicomponent fibers are taught by U.S. Patent 5,108,820 to Kaneko et al., U.S. Patent 4,795,668 to Krueger et al., U.S. Patent 5,540,992 to Marcher et al., and U.S. Patent 5,336,552 to Strack et al., and 5,425,987 to Shawver, each being incorporated by reference in its entirety. Bicomponent fibers are also taught by U.S. Patent 5,382,400 to Pike et al., incorporated by reference in its entirety. For two component fibers, the polymers may be present in ratios of 75/25, 50/50, 25/75 or any other desired ratio. Additionally, polymer additives such as processing aids, may be included in each zone.

A "layer" when used in the singular can have the dual meaning of a single element or a plurality of elements.

The term "machine direction" (MD) refers to the length of a fabric in the direction in which it is produced, as opposed to a "cross-machine direction" (CD) which refers to the width of a fabric in a direction generally perpendicular to the machine direction.

A "meltblown fiber" means fibers formed by extruding a molten thermoplastic material through a plurality of fine, usually circular, die capillaries as molten threads or filaments into converging high velocity heated gas (e.g., air) streams which attenuate the filaments of molten thermoplastic material to reduce their diameter, which may be to microfiber diameter. Thereafter, the meltblown fibers are carried by the high velocity gas stream and are deposited on a collecting surface to form a web of randomly dispersed meltblown fibers. Such a process is disclosed for example, in U.S. Patent 3,849,241 to Butin et al. which is incorporated herein in its entirety. Meltblown fibers are microfibers which may be continuous or discontinuous, are generally smaller than about 0.6 denier, and are generally self bonding when deposited onto a collecting surface. Meltblown fibers used in the present invention are preferably substantially continuous in length.

A "meltspun" fiber refers generically to a fiber which is formed from a molten polymer by a fiber-forming extrusion process, for example, such as are made by the meltblown and spunbond processes.

As used herein "highly elastic" or " highly elastomeric" refers to material which, upon application of a biasing force, is extensible or elongatable in at least one direction and returns approximately to its original dimensions after the force is removed. For example, an elongated material having a biased length which is at least 50 percent greater than its relaxed unbiased length, and which will recover to within at least 50 percent of its elongation upon release of the elongating force within a short period of time, such as in one (1) minute of release of the biasing (elongating) force. A hypothetical example would be a one (1) inch sample of a material which is elongatable to at least 1.50 inches and which, upon release of the biasing force, will recover to a length of not more than 1.25 inches within 1 minute.

As used herein "elastic" or "elastomeric" refers to material which, upon application of a biasing force, is extensible or elongatable in at least one direction and returns close to its original dimensions after the force is removed. For example, an elongated material having a biased length which is at least 50 percent greater than its relaxed unbiased length, and which will recover to within at least 25 percent of its elongation upon release of the elongating force within a short period of time, such as in one (1) minute of release of the biasing (elongating) force. A hypothetical example would be a one (1) inch sample of a material which is elongatable to at least 1.50 inches and which, upon release of the biasing force, will recover to a length of not more than 1.375 inches within 1 minute.

As used herein the term "percent stretch" refers to the ratio determined by measuring the increase in the stretched dimension and dividing that value by the original dimension. i.e. (increase in stretched dimension/original dimension) x 100.

As used herein the term "set" refers to retained elongation in a material sample following the elongation and recovery, i.e. after the material has been stretched and allowed to relax.

As used herein the term "percent set" (Tension Set) is the measure of the amount of the material stretched from its original length after being cycled. The remaining strain after the removal of the applied stress is measured as the percent set. The percent set can be described as where the retraction curve of a cycle crosses the elongation axis, and as further discussed below and is represented by the following formula:

$$\frac{\text{Final length-Initial length}}{\text{Stretched length-Initial length}} \times 100$$

As used herein, the term "drawn" shall refer to the action of elongating a molten stream of thermoplastic polymer and the term, "stretch" shall refer to the action of elongating a stream of elastomer polymer.

As used herein, the term "inelastic" or "nonelastic" refers to any material which does not fall within the definition of "elastic" above.

The "hysteresis value" is determined by first elongating a sample to an ultimate elongation of a given percentage (such as 50 or 100 percent) and then allowing the sample to retract to an amount where the amount of resistance is zero. For the purposes of this application, the term ultimate elongation should be understood to mean a predefined elongation percentage. For the purposes of this application, the hysteresis value determining numbers (and as further explained below in the test method section) are read for instance at the 50 percent and 100 percent total ultimate elongation, in either the machine or the cross-machine directions.

$$\% \text{ Hysteresis Loss} = \frac{\text{Energy Extension} - \text{Energy Retraction}}{\text{Energy Extension}} \times 100$$

A "nonwoven" and a "nonwoven web" refer to materials and webs of material which are formed without the aid of a textile weaving or knitting process.

The term "polymers" includes, but is not limited to, homopolymers, copolymers, such as for example, block, graft, random and alternating copolymers, terpolymers, etc. and blends and modifications thereof. Furthermore, unless otherwise specifically limited, the term polymer shall include all possible geometrical configurations of the material. These configurations include, but are not limited to isotactic, syndiotactic and atactic symmetries.

Words of degree, such as "about", "substantially", and the like are used herein in the sense of at, or nearly at, when given the manufacturing and material tolerances inherent in the stated circumstances and are used to prevent the unscrupulous infringer from unfairly taking advantage of the invention disclosure where exact or absolute figures are stated as an aid to understanding the invention.

A "spunbond fiber" refers to small diameter fibers which are formed by extruding molten thermoplastic material as filaments from a plurality of fine capillaries of a spinnerette having a circular or other configuration, with the diameter of the extruded filaments then being rapidly reduced as by, for example, in U.S. Patent 4,340,563 to Appel et al., and U.S. Patent

3,692,618 to Dorschner et al., U.S. Patent 3,802,817 to Matsuki et al., U.S. Patents 3,338,992 and 3,341,394 to Kinney, U.S. Patent 3,502,763 to Hartmann, U.S. Patent 3,502,538 to Petersen, and U.S. Patent 3,542,615 to Dobo et al., each of which is incorporated herein in its entirety by reference. Spunbond fibers are quenched and generally not tacky when they are deposited onto a collecting surface, since they are often made from polyolefins. Spunbond fibers are generally continuous and often have average deniers larger than about 0.3, more particularly, between about 0.6 and 10.

The term "elastomer" shall be used to describe a thermoplastic material which demonstrates elastic recovery following stretching.

The terms "kink" and "curl" shall refer to a structural formation in a fiber, in which part of an extruded fiber is bent so as to include a non-linear configuration, such as by passing over itself.

The term "crimp" shall refer to a repeating curl within a fiber and includes helical formations, coils or curls along the fiber length.

The term "corrugation" shall refer to fiber surface topography in which at least a portion of the surface of a fiber appears to be gathered along a central fiber core. Such surface topography is typically caused by a gathering of a sheath component along the longitudinal axis (and core component) in a bicomponent fiber.

These terms may be further defined with additional language in the remaining portions of the specification.

Test Methods:

For the purposes of this application, the following test methods were employed.

Extension/Retraction Test: Sintech tests included a five-cycle, 50 or 100 percent ultimate (target) elongation extension test (that is a predefined point of elongation of a given percentage as noted). For the 50 percent ultimate elongation extension test, for example, the sample is repeatedly elongated to an ultimate elongation of 50 percent and then allowed to retract to the original gauge length, five times. Testing is done on the Sintech 1/S or 2/S equipment utilizing TESTWORKS for Windows 3.02 software to record data. In conducting an extension /retraction test, a 3 inch (7.62 cm) wide sample of the material is held within clamps (4 inch (10.16 cm) gauge length) and pulled to a target elongation of either 50, or 100 percent

at a rate of 500 mm/min, and returned to the original distance, typically of four inches or otherwise noted, for five cycles. The test was done at ambient temperature and humidity conditions.

Hysteresis loss may be calculated in accordance with the following equation as noted:

$$\%\text{Hyst. Loss (Energy)} = \frac{(\text{area under Extension curve UP}) - (\text{area under Retraction curve DOWN})}{(\text{area under Extension curve UP})} \times 100$$

This determines the energy hysteresis.

Fiber Length per Bond Spacing Measurement:Test

Samples of the nonwoven materials were submitted to MVA Labs, Inc. (Norcross, GA) for the Backscatter Electron Detection / High-Contrast (BSE/HICON) test method using a JEOL scanning electron microscope (Peabody, MA) (SEM). Surfaces of the non-woven materials were photographed at 25 X magnification, and twelve (12) Polaroid photos (Cambridge, MA) were assembled into two (2) photomontages. The key image features in the photos are bond-point pairs (BPP's), placed diagonally from one direction for six (6) photos; then diagonally from the other direction for the other six (6) photos. The process of BSE/HICON photography; equipment used; and montage preparation has been described in US Patent 5,743,999, Kamps, et.al.; US Patent 5,411,636, Hermans, et.al.; and US Patent 5,492, 598, Hermans, et.al. each incorporated by reference in their entirety. These all refer to cross-section work; however, this surface photography uses the same procedure and equipment, but without liquid-nitrogen cuts; edge-view mounting; and photo-editing.

The photomontages are then individually placed on a 6-inch high box (here, auto-stage) covered with black cloth, itself on a Kreonite Mobile Studio macro-viewer (J. Kelly, Darien, IL). Image preparation is performed by viewing individual bond-point pairs with a 35-mm Nikon lens with F-to-C adapter (OEM Sales, Melville, NY). The "TV camera" (scanner) is positioned at 70 cm over the photos to just bracket the photo's image. Illumination is provided by four (4) 150-watt flood lamps, controlled by a variable-voltage transformer. The photomontages were placed under a glass plate to keep them flat. Examples of the

BSE/HICON photomontages from two extreme cases are shown as FIG. 3E (50/50 PP) and FIG. 3F (90/10 PP).

Analysis is performed using a Leica/Cambridge Quantimet 970 Image Analysis System (Bannockburn, IL). Other equivalent systems from the same manufacturer can also be used. Individual BPP's were imaged left-to-right across the monitor, and white masking strips of paper were laid at upper and lower bond tangents to enclose the fiber region between them. In this region, a variable frame was then placed to isolate the inter-bond fibers, and the routine listed below was run. The total length of fibers (FFL) was averaged from three (3) BPP's, and this average divided by the average frame width, to obtain a Fiber-Length-per-Field-Width (FL/FW), a dimensionless number. In addition, the average area occupied by fibers over the three fields was obtained, and this was divided by the FFL to obtain an average fiber diameter in microns. The four groups of numbers were treated by a Student's "t" analysis (N=4) for final means and confidence limits. In particular, the following routine, was run.

Program

Cond. 35 MM lens: Pole POSN = 70 CM; 4 Floods:Autostge as spacer
Enter specimen identity
Pause message
Please set white level at 1.05 by light adjustment...
Scanner (No. 2 Chalnicon LV= 0.00 Sens = 1.46 Pause)
Subrtn Standard
Load shading Corrector (pattern – std)
Calibrate User Specified (Cal Value= 4.467 Microns per pixel)
Detect 2D (Darker than 35. Delin)
TOTAREA := 0.
TOTWIDTH :=0.
FIBDIAM :=0.
TOTFIBDIA :=0.
TOTFIBCT :=0.
TOTFFL := 0.
TOTPW :=0.
TOTPH :=0.

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TOTFIELDS :=0.
For FIELD

Pause Message
Please adjust Rectangular Mask and White Level...
Scanner (No. 2 Chalnicon LV=0.00 Sens = 1.46 Pause)
Detect 2D (Darker than 0. Delin.)
Pause Message
Please Position Image Frame Over Masked Area...
Image Frame (Pause) is Rectangle (X: 402. Y: 130. W: 374. H: 338.)
Live Frame is Standard Live Frame
TOTWIDTH := TOTWIDTH + I.FRAM.WR  *  CAL.CONST
Detect 2D (Lighter than 36. Delin)
Amend (Open by 1-Horizontally)
Measure field-Parameters into array FIELD
TOTAREA := TOTAREA + FIELD AREA
Detect 2D (Darker than 34.Delin)
Amend (Close by 1- Horizontally)
Amend (Inverse Skeleton- by 30)
Image Transfer from Invert A to Binary Output
Pause Message
Please Check Image...
Selected Display (Binary A) (Frame)
Pause
Measure field-Parameters into array FILED
TOTFFL := TOTFFL + (FIELD PERIMETER/2.)
TOTPW := TOTPW + FIELD V. PROJECT
TOTPH := TOTPH + FIELD H.PROJECT
TOTFIELDS := TOTFIELDS + 1
Pause Message
Please Choose Another Field.or "Finish"...
Selected Display (Binary A) (Frame)
Pause
Next FIELD
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Print " "
Print "AVE FIBE DIAM (UM)=".TOTAREA/TOTFFL
Print " "
Print "AVE AREA OF FIBERS (SQ UM) = ". TOTAREA/TOTFIELDS
Print " "
Print "AVE LENGTH OF FIBERS (UM)=". TOTFFL/TOTFIELDS
Print " "
Print " AVE PROJ HT OF FIBERS (UM) =". TOTPH/TOTFIELDS
Print " "
Print " AVE PROJ WIDTH OF FIBERS (UM) =" . TOTPW/TOTFIELDS
Print " "
Print "# OF FIELDS=". TOTFIELDS." AVE FIELD WIDTH (UM)=". TOTWIDTH/TOTFIELDS
For LOOPCOUNT = 1 to 5
Print " "
Next
END OF PROGRAM
```

Disclosed are highly extensible and/or recoverable nonwoven webs with controlled extension and retraction load characteristics. In one embodiment, such webs are prepared from bicomponent spunbond fibers in either the side-by-side or sheath/core configuration with a fiber forming elastomer and a second thermoplastic polymer. The second thermoplastic polymer need not be an elastomer. While such nonwoven webs may be produced in two steps, those being spinning and post-spinning stretching and/or drawing, it has been found that such webs may more efficiently be produced in one step, that is through the simultaneous application of sufficient spinline tension while spinning, through the use of sufficient stretching and/or drawing within a fiber draw unit, under a certain spinline quenching temperature and speed distribution, thus ensuring certain fiber laydown to the web and also sufficiently high spinline stress.

The term post-spinning stretching is meant to indicate the use of a down stream processing technique to stretch or incrementally stretch such material. (stretching after bonding). For instance, such down stream processing techniques may include sequential stretch rolls which operate at progressively higher speeds. In certain instances, such down stream processing steps may be beneficial, depending on the polymeric materials in the

extruded web, or the desire to prestretch elastic materials in preparation for final use, as described at a later point in this application.

Depending on the polymer system, the ratio and configuration of the two polymers in the fiber, and the degree of tension in the spinline (fiber forming) process, the extension and retraction forces demonstrated by the resulting fibrous web can be controlled in this invention. If desired, the stretch-to-stop property could also be adjusted in this fashion as well, for materials that incorporate the webs in a laminate. For the purposes of this application, the stretch-to-stop property shall mean that a 3 inch (7.62 cm)strip reaches 2000 gram force tension at which typical customers feel "ceasing stretching".

If the particular elastomer utilized normally gives a rubbery hand or feel, it has been found that spun webs in which an eccentric or concentric sheath/core bicomponent fiber configuration is desirable in order to uniformly cover the elastomer core with the thermoplastic polymer sheath and alleviate the rubbery feel. Otherwise, the non- or less rubbery side of a side-by-side bicomponent fiber can also be used in a highly crimped form with the elastomer component kept in the middle section of the helix. The material may then be readily made as cross-directional stretchable to at least 30 percent extensible under 500 gf (grams force)/3 inch load. The material may demonstrate greater than 1 grams force over 3 inches (7.62 cm) retraction force at 50 % extension on the 100 % CD extension first cycle test.

The material may also demonstrate CD/MD stretch as greater than 30% extensible under 500 gram force over 3 inches (7.62 cm) load in the MD/CD. The material may be made to demonstrate greater than 1 gram force (gf) /3 inches (7.62 cm) retraction force at 50% extension on the 100% CD extension first cycle test.

Such desired extension and retraction load characteristics are achieved by laying down flexible fibers in loops, kinks, and crimps using the inventive process, with certain fiber orientation during spunbond web formation, followed by stabilizing the web by intermittent point bonding in a pattern with a given spacing. Then, the resulting actual fiber length between bond points, or the "fiber length per bond spacing" (FL/BS) largely determines the early stages of the web extension, exhibiting a low extension load.

In certain circumstances, the fibers also exhibit a corrugated surface topography where the surface of the fibers have gathered along the length of the elastomeric core. In certain circumstances, as the fibers are stretched, the gathering provides additional give for the material.

It is desirable in some embodiments to activate these flexible fibers, if the extension and retraction loads during the later stage of the extension are desired to be controlled. A wide range of fiber flexibility can be obtained with the nature of the first and second component polymers, amount of the elastomer used, and geometry of the bicomponent fiber cross section being altered. Such flexible bicomponent fibers are spun and webs formed at a sufficiently high ratio of the spinline speed to the forming wire speed, or fiber condensation ratio, adjusting the fiber length per bond spacing with a given bond pattern. Sufficiently high spinline stress which contains suitable spinline temperature profiles will then elasticize these flexible fibers as spun, if desired. Optionally, such elasticization can be done by post mechanical drawing.

It is often desired to leverage the tension loads in the MD and CD separately for the biaxially stretchable material in certain applications. For example, the tension can be increased in the CD but decreased in the MD by stretching the material in the CD, utilizing MD oriented grooved rolls, followed by heat setting the material. The degree of such material stretching to orient fibers in the CD is much lower than the value for further elasticizing fibers, which requires deforming the sheath polymer in a sheath/core multicomponent fiber configuration beyond its yield point.

As an example of this alternative, CD-orienting heat setting testing was completed by extending 3"x 4" (CD x MD) samples of material 100% in the machine cross-direction and clamping them to a plexiglass plate in an extended state. The samples were placed in an oven at 160°F for 30 minutes. Afterwards, extension/retraction testing was performed in the CD and MD at 100 percent maximum extension. The tension values were compared to tensions of control, or unexposed, material. Results from this testing confirm expected increases in CD and decreases in MD tensions and are reflected in Figures 18 and 19. Figure 18 illustrates the effects of heat setting on CD tension of Kraton (K) /Polypropylene (PP); 90/10; 0.6 osy (Normalized) material. That is, it demonstrates the effects of CD orienting heat setting on CD tensions. Figure 19 illustrates the effects of heat setting on MD tensions of Kraton/PP; 90/10; 0.6 osy (Normalized) material. That is, it illustrates the effects of CD-orienting heat setting on MD tensions.

If the material is desired to be highly extensible and retractable via elasticized sheath/core bicomponent fibers, the ratio of the first component elastomer to the second component thermoplastic polymer need be higher than the typical value of the bicomponent spunbond, particularly in the sheath/core configuration. For instance, it is desirable to have at least between 70 and 98 percent core elastomer component (by weight) in such a material.

Alternatively, it is desirable to have at least between 70 and 90 percent core elastomer component (by weight) in such a material. By uniformly distributing the minute amount of the second component without altering its rheological property, bicomponent fibers with the desired properties are achievable.

Referring to Figure 1, a schematic of equipment used to practice the method of forming fibers into a web is depicted. The method includes the steps of co-extruding through a spunbond apparatus a first component contained in hopper 11 and a second component contained in hopper 12. The first and second components respectively, can be in the form of solid resin pellets or small particles or granules. The first component is positioned in the hopper 11 from which it can be metered and routed through a conduit to an extruder 13. Likewise, the second component contained in hopper 12 can be metered and routed through a conduit to a second extruder 14.

The first component is a material that can be spun or otherwise formed into a continuous fiber. When the first component is formed into a fiber, the fiber must be capable of being stretched and have a high recovery percentage. Desirably, the first component is an elastomeric material. Suitable elastomeric materials that can be used for the first component include melt extrudable thermoplastic elastomers such as a polyurethane elastomer, a copolyether ester, a polyether block polyamide copolymer, an ethylene vinyl acetate (EVA) elastomer, a styrenic block copolymer, an olefinic elastomer or plastomer, as well as other elastomers known to those skilled in the polymer art. Particularly suitable elastomers include styrenic block copolymers such as those available from KRATON® Polymers. KRATON® is a registered trademark of Kraton Polymers having an office in Houston, Texas.

The second component, like the first component, is a material that can be spun or otherwise formed into a continuous fiber. Since the first component (elastomer) does not typically have sufficiently high melt strength to be spun at the high speed of the spunbond process, the second component should desirably have sufficiently high melt strength to reinforce the first component without breaking spinlines (fibers).

When the first and second components are formed into a linear fiber, the fiber may be capable of retracting or contracting from a stretched condition in order for the linear fiber to be useful as a stretchable component of a disposable consumer product. As referred to herein, the term "retracting" has the same meaning as "contracting". For certain applications where high retraction force is not required, however, it should be appreciated that stretchable material can also be made of looped, kinked, or crimped fibers, but not with

retractable fibers, or with less retractable fibers which have either limited or no memory. Then, the material stretching characteristics will be different from that of retracting fibers, as shall be described at a later point in this application.

The second component can be formed from a polyolefin such as polyethylene or polypropylene, a polyester, a polyether or a polyamide. Still other suitable polyolefinic materials that can be used for the second component include random copolymers, such as a random copolymer containing propylene and ethylene, or materials such as blends, including but not limited to, polypropylene/polybutylene blends and copolymers.

The second component can also be formed from a melt extrudable thermoplastic material that provides permanent deformation upon stretching, that is, demonstrates a permanent set. Such materials include, but are not limited to polyamides.

It is desirable that the second component have a lower recovery when stretched than the first component. Such materials can be selected that would not demonstrate rubbery hand or stickiness to the touch and could be extruded in a thin consistent layer so as to sufficiently cover an elastomeric material contained adjacent to such. By covering a rubbery or sticky material with such second component, the sticky component could be used to provide elasticity but without the "sticky" hand. Depending on the particular second component utilized, the sheath component of a sheath/core bicomponent material may or may not demonstrate surface corrugations. For instance, it has been found that while the use of polypropylene, or its blend with 10% polybutylene copolymer in the sheath may lead to corrugated surface topographies, the use of polyethylene in a sheath may lead to relatively smooth surfaces.

Referring again to Figure 1, the first and second components, respectively, are separately co-extruded in the two extruders 13 and 14. The first and second extruders, 13 and 14 respectively, function in a manner that is well known to those skilled in the extrusion art. In short, the solid resin pellets or small particles or granules, are first heated up above their melting temperature and advanced along a path by a rotating auger. The first component is routed through a first conduit while the second component is simultaneously routed through a second conduit, and both flow streams are directed into a spin pack 16. A pump 15, can be positioned across one or both of the conduits to regulate volumetric distribution, if needed.

The spin pack 16 is a device for making synthetic fibers. The spin pack 16 includes a bottom plate (not shown) having a plurality of holes or openings through which the extruded

material flows. The spin pack desirably includes an assembly of distribution plates which directs the first and second components in such a way to form a desirable bicomponent fiber cross section geometry. When highly elasticized fibers in the sheath/core configuration are needed, the second component amount is extremely small when compared with the typical bicomponent spunbond fiber forming amounts for bicomponent materials. In accomplishing this fiber formation, a distribution plate may be utilized which restricts the second component flow from its reservoir melt pool around the core elastomer flow, thus ensuring the back pressure in the melt pool and thus uniformly covering the elastomer core. The degree of restriction depends on the second component flow rate and viscosity. Otherwise, the bicomponent spin pack yields spinlines (fibers) with the first component elastomer partially covered with the second component, leading to a poor final product. Such spinlines are so sticky as to become roped together, yielding unacceptably poor formation and rubbery hand in the material. Also, the web is so sticky that light basis weight material cannot be made and such a web's extension load is unacceptably high.

The number of openings per square inch in the spinpack can range from about 5 to about 500 openings per square inch. Desirably, the number of openings per square inch in the spin pack 16 is from about 25 to about 250. More desirably, the number of openings per square inch in the spin pack 16 is from about 125 to about 225. The size of each of the openings in the spin pack 16 can vary. A typical size opening can range from about 0.1 millimeter (mm) to about 2.0 mm in diameter. Desirably, the size of each of the openings in the spin pack 16 can range from about 0.3 mm to about 1.0 mm in diameter. More desirably, the size of each of the openings in the spin pack 16 can range from about 0.4 mm to about 0.8 mm in diameter.

It should be noted that the openings in the spin pack 16 do not have to be round or circular in cross-section but can have a bilobal, trilobal, square, triangular, rectangular, oval or any other geometrical cross-sectional configuration that is desired.

Referring again to Fig. 1, the first and second components are directed into the spin pack 16 and are routed through the openings formed in the bottom plate in such a fashion that the first component will form a core of an extruded fiber while the second component will form a sheath of an extruded fiber, surrounding the outside circumference of the core (assuming the spinback is designed for a sheath/core configuration). It should be noted that the first component could just as easily form the sheath while the second component could form the core, if desired, but with the appropriate switch in hopper components. This

core/sheath arrangement produces one configuration (Figure 2B) of a linear, bicomponent fiber. Bicomponent fibers having other cross-sectional configurations can also be produced using a spin pack 16. For example, as seen in Figure 2, the bicomponent fiber can have a side by side configuration 2A or a core/sheath design (2B and 2C). In the 2C fiber, the core is offset coaxially from the sheath. The configuration 2D is very similar to 2A, but the first component is covered with the second to enhance the twisting action forming helical crimped fibers. Even tighter crimps could be generated with the longer distance between the center of gravity of the first component cross section and that of the second component, as shown in 2E through 2G, for example. Then, the amount of the first component elastomer is not needed as much as in the concentric sheath/core configuration. It should be recognized that with the side by side bicomponent configuration, undesirable rubbery hand or stickiness, as a result of exposed elastomer, may be present in a finished web. However, such rubbery hand could be minimized with tighter helical crimps, with the contracting elastomer tending to be positioned inside the helix.

One bicomponent fiber will be formed for each opening formed in the plate within the spin pack 16. This enables a plurality of continuous molten fibers, each having a predetermined diameter, to simultaneously exit the spin pack 16 at a first speed. Each linear, bicomponent fiber will be spaced apart and be separated from the adjacent fibers. The diameter of each bicomponent fiber will be dictated by the size of the openings formed in the bottom plate of the spinpack. For example, as stated above, if the diameter of the holes or openings in the bottom plate range from about 0.1 mm to about 2.0 mm, then each of the molten fibers can have an initial diameter which ranges from about 0.1 mm to about 2.0 mm. There is a tendency for the molten fibers to sometimes swell in cross-sectional area once they exit the opening formed in the plate but this expansion is relatively small.

Referring again to Fig. 1, the plurality of continuous molten fibers 56 are routed through a quench zone 18 to form a plurality of cooled linear fibers. In the quench zone 18, the continuous molten fibers are contacted by one or more streams of air. Normally, the temperature of the continuous molten fibers exiting the spin pack 16 and entering the quench zone 18 will be in the range of from about 150°C to about 250°C. Within the quench zone 18, the continuous molten fibers are contacted and surrounded by lower temperature air. The temperature of the air can range from about 0°C to about 120°C. Desirably, the air is cooled or chilled so as to quickly cool the molten fibers. However, for certain materials used to form the bicomponent fibers; it is advantageous to use ambient air or even heated

air. However, for most elastomeric materials, the air is cooled or chilled to a temperature of from about 0°C to about 40°C. More desirably, the air is cooled or chilled to a temperature of from about 15°C to about 30°C. The lower temperature air can be directed toward the molten fibers at various angles but a horizontal or downward angle seems to work well. The velocity of the incoming air can be maintained or adjusted so as to efficiently cool the molten fibers.

The cooled or chilled air will cause the continuous molten fibers/spinlines to solidify, and_crystallize, if crystallizable, or phase separate typically in the elastomer core, and form a plurality of continuous cooled bicomponent fibers. The ability to crystallize during the process will of course also depend in part on the crystallinity rate of the material.

The cooled fibers are still linear in configuration at this time. The cooled fibers will be at a temperature below the melting temperature of the first and second components from which the fibers were formed. The cooled fibers may have a soft plastic consistency at this stage.

The plurality of continuous cooled fibers 19 are then routed to a draw unit 20. The draw unit 20 can be vertically located below the quenching zone 18. The draw unit 20 should have sufficient height of 30-60 inches(measured by 62) to provide an adequate distance over which the cooled fibers can be drawn or pulled. Drawing/pulling downward involves subjecting the cooled fibers to a high velocity air stream jetted though a narrow gap(s) by pressurized air, that will pull, stretch or draw the molten material exiting the spin pack 16 downward. The air pressure can range from about 1 pound per square inch (psi) to about 100 psi depending on factors such as the gap size. Desirably, the air pressure can range from about 2 psi to about 50 psi. More desirably, the air pressure can range from about 3 psi to about 20 psi. The velocity of the high pressure aspirated air can be maintained or adjusted so as to efficiently draw the cooled fibers.

The pressurized air can be at ambient temperature of about 25°C or the pressurized air can be either hotter or colder depending upon one's preference. The cooled fibers are stetched/drawn down mainly from the molten state and not from the cooled state. The downward force of the high velocity air in the draw unit 20 will cause the molten material to be lengthened and elongated into solid fibers. Lengthening of the molten material will usually shape, narrow, distort, or otherwise change the cross-sectional area of the solid fibers. For example, if the molten material has a round or circular cross-sectional area upon exiting the spin pack 16, the outside diameter of the solid fibers will be reduced. The amount that the diameter of the solid linear fibers is reduced will depend upon several factors, including the

amount the molten material is drawn, the distance over which the fibers are drawn, the distribution of air temperature and velocity, the pressure and temperature of the air used to draw the fibers, the distance between the spin plate and the entrance of the draw unit, the length of the draw unit , etc. Desirably, the diameter of the solid linear fibers will range from about 5 microns to about 100 microns. More desirably, the diameter of the solid linear fibers will range from about 10 microns to about 50 microns. Most desirably, the diameter of the solid linear fibers will range from about 10 microns to about 30 microns after exiting the fiber draw unit.

Upon exiting the draw unit 20, the cooled fibers will be solid fibers. The tension created between the spinplate and the fiber draw unit, the spinline tension, is dependent on the spinning speed coming out of the spinplate, quenched spinline temperature distribution, and the air flow in the draw unit. It is this tension that acts to create the fibers demonstrating the desired attributes and is important to tailor the fiber elastic properties. The higher tension, after the spinline is sufficiently cooled, renders more retraction of the elastomer component, enhancing the fiber extensibility. However, too high spinline tension propagated to the spin plate beyond a certain value causes spinline breakage. Such spinline tension distribution can be maximized via the spinline temperature profile for a given fiber size.

In one embodiment, the extruded molten spinline (fiber) is passed through a delayed quench zone 60, immediately below the spin plate, 0.5 – 6 inches high, which consists of warm, stagnant air or cross flowing air. When the fiber cooling is too fast, the molten spinline prematurely forms solid skin, requiring accordingly high tension to attenuate into a desired fiber size. If this tension exceeds the cohesive force of the spin line polymers, it will break up the fibers. Such delayed quenching allows the spinline to easily deform to a certain size in order to obtain the desired final fiber size. Then, the spinline is quickly quenched with cross flowing quench air. This quench air is aspirated through several boxes each on upstream and downstream sides 57 and 58 at between 140 -170 ft/min velocities from the top to the bottom of the quench zone for example. The turbulence of the quench air is desirably controlled to minimize spinline (fiber) touching during such cooling. The total spinline length between the spin plate and the entrance of the draw unit is then typically between about 30-100 inches (76.2 -254 cm) including the makeup air zone 63 under the quench zone. As the high velocity air exits from the end of the draw unit, it entrains room air and its velocity is slowed down, until it exhausts through the vacuum boxes under the forming surfaces. During such room air entrainment, air turbulence with a range of different scales is generated, causing

fibers to become kinked and looped, as formed on the forming surface. The typical forming distance 63 between the end of the draw unit nozzle and the forming surface is typically 5 to 20 inches with 0.2 to 1 inch draw unit nozzles being employed.

Typically, the forming air, namely the quench and makeup air, is aspirated into the top of the fiber draw unit at about 10,000 to 14,000 ft/min, and exits at the bottom at about 12,000-16,000 ft/min. Such fiber draw unit air is accelerated by the momentum jetted by the high pressure air through the very narrow slots (2), which velocity can reach as much as about 40,000 to 60,000 ft/min. The spinline is thus highly tensioned by the air drag force in such airflow field within the fiber draw unit.

The fibers are then allowed to relax as they exit the fiber draw unit and laid down on the forming surface through which the most of the forming air is exhausted. The speed at which the forming surface carries away the formed fibers is essentially less than that at which the fibers exit the draw unit. The relaxation acts to cause the thin sheath fibers to contract, and the retracting force of the stretched core elastomer is sufficiently high enough to cause the bunching or gathering of the stretched thermoplastic sheath in some of the sheath/core configurations, and in some instances kink or curl in the fibers. In the side/side configuration, on the other hand, such contraction predictably causes helical crimps in the fibers. The bicomponent configuration which includes a center of gravity for the first component that does not coincide with that of the second component in the fiber cross section, such as in the eccentric sheath/core bicomponent configuration particularly results in crimped or coiled fibers. This fiber contraction depends, thus, on the elastic properties of the first component elastomer, the yield tensile property of the second component thermoplastic polymer and the geometry of the fiber cross section.

As previously indicated, the fiber contraction, depending on the polymers employed, sometimes results in a corrugated topography (bunching or gathering) of the thin sheath of the bicomponent fibers, or alternatively, a smooth surface, when the sheath polymer is itself recoverable.

As previously indicated, the solid, linear fibers exiting the draw unit 20 are deposited onto a moving support or forming surface 23. The moving support 23 can be a continuous forming wire or belt that is driven by a drive roll while revolving about a guide roll 24. One or more guide rolls can be utilized if needed. Other types of moving supports known to those skilled in the art can also be utilized. The moving support 23 can be constructed as a fine, medium or coarse mesh having either no openings or a plurality of openings formed therein.

For example, the moving support 23 can have a configuration similar to a standard window screen or it can be tightly woven to resemble a wire or felt used by the paper industry in the formation of paper. A vacuum chamber 21 can optionally be positioned below the moving support 23 to facilitate accumulation of the solid, linear fibers onto the moving support 23. In Figure 1, the extrusion/spinning portion of the process is indicated generally by 25. The post-spinning process is indicated generally by 30.

Referring again to Fig. 1, the continuous linear fibers accumulate on the moving support 23 in a random orientation and form a nonwoven mat. The nonwoven mat is simply an accumulation of the continuous linear fibers at this point, and does not contain any melt points or bonds which would stabilize the fibers into a web. The thickness and basis weight of the mat will be dictated by the speed of the moving open support 23, the number and diameter of the continuous linear fibers deposited onto the moving support 23, as well as the speed at which the fibers are being deposited onto the moving support 23. The nonwoven mat is then optionally routed under a hot air knife 26 that directs one or more jets or streams of hot air against the mat. By "hot air" is meant air that has been heated to a predetermined elevated temperature. The exact temperature used will be determined based on the material used to form the bicomponent fibers. The hot air should be of a sufficient temperature to melt some of the fibers at points where such fibers contact, intersect or overlap adjacent fibers. The hot air causes some of the fibers to melt and adhere to adjacent fibers at a plurality of melt points. If used, the hot air is desirably between about 60 and 250 deg C. The temperature is of course dependent on the polymer types employed in the fiber, and in particular, the melting temperature of the outer sheath component, if a sheath-core material is being produced. If a side-by-side material is being produced, then the melting temperature of the nonelastic component is the threshhold temperature. Such hot air knives are taught, for example in U.S. Patent 5,707,468 to Arnold et al. which is incorporated by reference in its entirety. Alternatively, or in addition to the hot air knife, a set of compaction rolls 27 may be employed to compact the web.

The melt points from the hot air knife are therefore bonds formed at the intersection of two or more continuous fibers. The number of melt points formed can vary and will be determined by a number of factors: including the speed of the mat, the temperature of the hot air, the composition of the bicomponent fibers, the degree to which the continuous linear fibers are entangled, the basis weight of the mat , etc. For example, one could form from

about 10 to about 10,000 melt points per square inch. The continuous linear fibers adhered by the plurality of melt points forms a stabilized web.

Referring again to Fig.1, the stabilized web is then routed through a nip 32 (as part of a finishing operation 30) formed by a bond roll 34 and an anvil roll 36. The bond roll 34 and the anvil roll 36 are typically heated to an elevated temperature. Such temperature may be between 60 and 250 deg. C. The bond roll 34 contains one or more outwardly projecting nubs or protuberances. The nubs or protuberances extend outward from the outer circumference of the bond roll 34 and are sized and shaped to create a plurality of bonds in the stabilized web. Such can be clearly seen in Fig. 3E, by the larger lighter , circular shaped structures in the web 45. Once the stabilized web has the bonds formed therein, it becomes a bonded web. The bond roll 34 and the anvil roll 36 can be rotated as noted, as the stabilized web passes through the nip. The nubs or protuberances will penetrate a predetermined depth into the stabilized web and form the bonds. The exact number and location of the bonds in the bonded web will be dictated by the position and configuration of the nubs or protuberances formed on the outer circumference of the bond roll. Desirably, at least one bond per square inch is formed in the bonded web. More desirably, from about 20 to about 500 bonds per square inch are formed in the bonded web. Most desirably, at least about 30 bonds per square inch are formed in the bonded web.

It should be appreciated that as the spinline diameter reaches the final fiber size before being deposited on the forming surface and subjected to stabilization and bonding, the fiber size may be in the range of 1 to 10 denier. For example, the fiber size may be approximately 2 denier, from 0.6 grams/min/hole of the spin plate hole throughput. The spinline velocity reaches approximately 2700 m/min compared with the typical forming surface speed of approximately 61 m/min. The condensation ratio, that is the ratio of the spinline velocity to the forming surface is thus as high as about 44 before the elastomer portion is contracted at the forming surface.

The spinlines when formed, are generally straight. However they make loops and kinks as they are laid down on the forming wire. The size of loops depends in part, on the condensation ratio, the flexural modulus of the quenched spinlines and the contraction. The flexural modulus can be readily altered via the two polymer moduli and more readily by the amount of the elastomer in the sheath/core bicomponent fibers.

When the distance between the center of gravity of the first component and the second component in the quenched spinline is not zero, the relaxed or retracted spinlines on

the forming wire become crimped. The degree of crimps depends on the distance, and retraction behaviors of the two polymers in the extruded fibers.

It is the three pronged shaping of the fibers, namely, fiber loops, kinks/curls or crimps, and corrugations, along with the general fiber orientation within the web, that provides much of the elongatability of the formed nonwoven material, since a force pulling on the produced web material would first have to pull out the looping and curling, and then the corrugation or bunching (if it is present), followed by reorienting the fibers towards the direction of pulling, before acting on the body of the fiber itself. Continued stress on the fiber would then in some circumstances act to perhaps rupture the sheath component and take advantage of the elastomeric core component.

Thus, the early stage of the material extension involves unkinking, un-looping, un-crimping and fiber rotation or reorientation, generally requiring low extension force, while the later stage extension involves largely pulling the fibers themselves. The combination of these actions provides the extension characteristics for a variety of applications.

It should be noted that the web material extension via fiber unlooping, unkinking, un-crimping rotating versus fiber pulling also depends to a degree, on inter-bond distance, as does the material retraction. In more general terms, the early stage of the material extension depends of the "fiber length per bond spacing" or the actual fiber length between bond points compared with the inter-bond distance. In other words, the extension and retraction of the web material can be altered via with shorter inter-bond distance, thereby exhibiting higher extension and retraction loads.

Further, as the amount of the elastomer component in the bicomponent fibers increases with a fixed bond pattern, the spinline (fiber) flexibility increases. The fiber loop size then decreases at a given condensation ratio, and the actual fiber length between bond points increases. However, such increase reaches a maximum value as the retraction force of the stressed elastomer component is sufficiently high enough to compress the thin sheath, increasing the apparent fiber diameter. Then, the material extension via fiber pulling plays a significant role in the material attributes.

Desirably, the basis weight of the web produced is between about 6 and 200 gsm in order to demonstrate the elastic attributes described. The bonded web may then optionally be stretched in at least one direction, and desirably, in two directions. For example, the bonded web may be stretched in either the machine direction, the cross direction, or in both directions, in order to further activate additional elasticity within the web.

For instance, the bonded web may be routed to a nip formed between a pair of rotating rolls. Each of the rolls would have a configured surface respectively. The configured surfaces are sized and configured to mate with one another and cause the bonded web to be stretched in the machine direction as it advances through the nip. The bonded web will be stretched in the machine direction into a lengthened web. Another option for such stretching is to use a series of rotating rolls to stretch the web in the machine direction. The rolls can be driven at different speeds, if desired.

This lengthened web can then be routed through a nip formed between a pair of rotating rolls. Each of the rolls has a configured surface, respectively. The configured surfaces are sized and configured to mate with one another and cause the width or cross direction of the web to be increased as it passes through the nip into a wider. It should be noted that other mechanisms known to those skilled in the art can be used to stretch the web in either one or two directions. One such option is to use grippers that attach to the side edges of the web and stretch the web in the cross direction. A second option is to use a tenter frame to stretch the web.

The stretching can occur at room temperature of approximately 25°C. Desirably, the stretching can also occur at an elevated temperature in the range of from about 25°C to about 100°C. More desirably, the stretching can occur at an elevated temperature in the range of from about 50°C to about 90°C. It should be noted that a plurality of several pairs of mating rollers can be used to gradually increase the percentage of stretch in the web if desired. The stretched web is then allowed to relax after passing through the nip(s). This relaxation allows the stretched web to retract.

Increased elastic performance of such elastomeric/thermoplastic bicomponent materials may be achieved via the following process which is particularly effective with certain low performance elastomeric materials. Following manufacture of such a web into a sheet, as previously described, such sheet may then be given a one-time stretch, for instance to approximately 75 % of its peak elongation, that is, the elongation of the material at break. Such material should then be allowed to recover. Subsequent elastic properties of the web are then improved. This should be effective for both sheath core materials with higher relative sheath percentages and poor to no machine direction elastic properties. For instance, by utilizing a single site -catalyzed elastomeric core, cost savings can be achieved without unduly sacrificing elastic performance. By stretching a material with a single site-catalyzed elastomeric core, such as metallocene catalyzed polyethylene having a density less than 0.9, one would achieve both a

permanent deformation of the outer sheath and remove the poor "first" stretch (which metallocene catalyzed materials typically demonstrate) out of the process. If it is desired that materials ultimately stretch 50 % in use, the material could be essentially prestretched, such that it delivers the necessary elongation during use. Upon subsequent stretching, products employing the material would then satisfy this objective.

In an alternative embodiment, only part of the sheet material could be prestretched, so as to incur easy stretch in part, while the remainder of the material would only be stretched with a higher force. Furthermore, some area on the material could have machine direction stretch, while other areas could have cross-directional stretch. Such machine or cross-machine directional stretch could be achieved by running the formed material between two nips, S- wrap rolls arrangements, cross-machine oriented grooved rolls, or the like. Further, one could utilize tenter frames or machine direction oriented grooved rolls as well, as previously described.

In a one such embodiment (of CD stretch) of the above described stretching process, a large diameter roll system 50 , as seen in Figure 4A, may be utilized, which employs one large diameter roll 51 (of approximately 6 feet) with machine direction oriented valleys going deeply into the roll. These can be seen in the cross-sectional view of Figure 4B. A series of satellite rolls 52, 54, and 56 could also be employed with grooves that fit within the valleys of the larger diameter roll. The satellite rolls could be adjustable such that their depth within the grooves of the larger roll could be changed. In this fashion, the first satellite roll could push the material in, for example 4 inches, while the second satellite roll could push the material in, for example 8 inches and so on, until the material received the desired amount of stretch. The satellite rolls could be adjusted such that if less stretch is desired, the first could be pushed into the valleys of the bigger roll for example by 2 inches. The satellite roll system offers the material multiple gentle stretches with relaxation between each stretch, instead of one large stretch extension with standard grooved rolls.

Following this roll apparatus, an identical roll apparatus shifted one half cycle to the left could stretch the material that was not stretched in the first apparatus. The material could be pinched on the edges of the bigger roll by a belt 61 in a groove such that the material could not slide, but would have stretch.

In a further alternative embodiment, to achieve this stretch, a series of parallel rolls 80 as shown in Figure 5 may be used to stretch the material. The parallel rolls could consist of a three or more rolls, having smaller diameter rolls 84 on the exterior sides of the production line,

oriented in the machine direction, with a larger diameter roll 82 positioned between them. In this fashion, as material passes over the parallel rolls, the material would be stretched.

In still a further alternative embodiment, to achieve this stretch, a series of approximately 1 inch wide conveyor belts 90, as seen in Figure 6, with at least one going up 92 and the next going down 94 could be utilized. In this arrangement, the belts would form an "X" and the material would enter in one mouth of the "X". As the material traveled down the "X", part of the material would be caused to go up and part would be caused to go down in the process, thereby causing the stretching. The belts could be driven if desired.

In still another alternate embodiment, the polymer type is varied to provide for a range of elastomeric properties. For instance, one of the polymers may be a polypropylene of different melt flow rate depending on the ultimate application. For example, ziegler natta catalyzed polypropylene may be used in one application and single site catalyzed polypropylene may be used in another. Such polymers, which are known in the art as "metallocene", "single-site" or "constrained geometry" catalyzed polymers, are described in U.S. Patent No. 5,472,775 to Obijeski et al. and assigned to the Dow Chemical Company, the entire contents of which are incorporated herein by reference. The metallocene process generally uses a metallocene catalyst which is activated, i.e. ionized, by a co-catalyst. Examples of metallocene catalysts include bis(n-butylcyclopentadienyl)titanium dichloride, bis(n-butylcyclopentadienyl)zirconium dichloride, bis(cyclopentadienyl)scandium chloride, bis(indenyl)zirconium dichloride, bis(methylcyclopentadienyl)titanium dichloride, bis(methylcyclopentadienyl)zirconium dichloride, cobaltocene, cyclopentadienyltitanium trichloride, ferrocene, hafnocene dichloride, isopropyl(cyclopentadienyl,-1-flourenyl)zirconium dichloride, molybdocene dichloride, nickelocene, niobocene dichloride, ruthenocene, titanocene dichloride, zirconocene chloride hydride, and zirconocene dichloride, among others. A more exhaustive list of such compounds is included in U.S. Patent 5,374,696 to Rosen et al. and assigned to the Dow Chemical Company. Such compounds are also discussed in U.S. Patent 5,064,802 to Stevens et al. and also assigned to Dow. However, numerous other metallocene, single-site and/or similar catalyst systems are known in the art; see for example, U.S. Patent No. 5,539,124 to Etherton et al.; U.S. Patent No. 5,554,775 to Krishnamurti et al.; U.S. Patent No. 5,451,450 to Erderly et al. and The Encyclopedia of Chemical Technology, Kirk-Othemer, Fourth Edition, vol. 17, Olefinic Polymers, pp. 765-767 (John Wiley & Sons 1996); the entire content of the aforesaid patents being incorporated herein by reference.

Further, a blend of polypropylene with atacticity, syndiotacticity, or isotacticity may be employed in the sheath. The elastomeric component can be a blend of polyethylene with elastomeric resins such as Engage EG8200, Kratons, ESI, catalytically modified polyethylene and other low density metallocene catalyzed or Insite resins suitable for fiber formation.

The side-by-side PP/PE coextruded filaments of current nonwoven materials have resulted in webs with cross-direction extensibility so that when these webs are laminated to coextruded films, one could obtain a consumer product outercover with cross-direction extension at low loads. However, the process of cross-directional extension during use may be limited by the nonextensibility of the polymers of the filaments. Further, as the polypropylene and polyethylene are not compatible, the bond between the polypropylene and polyethylene filaments is weak and this is further weakened during web extension as the polyethylene does not have an extensibility. This problem may lead to delamination between the layers of the web and also poor abrasion resistance. In contrast, spunbond filaments made with an elastomeric polyethylene blend would be resilient and would extend more, thereby resulting in increased web cross-direction extensibility, and also exhibit higher interfiber bonding to prevent layer delamination and hence improved abrasion resistance.

It should also be recognized that the webs described herein may be part of a laminate structure, that itself may be utilized in a disposable consumer product, such as a laminate of webs or film components that are bonded by methods known in the art. Further, multilayered laminates of layers of the described webs are also within the scope of this invention. Such materials may used for example in a diaper as a liner, outercover facings, and may further be used as facings for a stretch bonded laminate or necked bonded laminate. Further, such materials may be additionally used as a necked stretched bonded laminate in order to give very high stretch properties.

Three sets of examples are provided to illustrate aspects of the inventive process for producing such material and the material itself. In the first set of examples which follow, the invention is illustrated as a cross-directional stretchable nonwoven web. In particular, the material demonstrated greater than 150 percent cross-directional extension at break, greater than 50 percent stretch under 500 gf/3 inch load in the cross-direction, greater than 1 gf/3 inch retraction force at 50 percent extension on a 100 percent first cycle test and less than 30 percent immediate set at 50 percent extension. Machine and cross-machine direction stretchable nonwoven webs have been demonstrated that showed similar results.

Fibers of core/sheath bicomponent samples Kraton/PP (90 percent core/10 percent sheath) and Kraton/PE (80 percent core/20 percent sheath), were made largely oriented in the MD direction. The effect of such fiber orientation on the extension and retraction loads is evident. These loads were much higher in the MD than in the CD. It should be noted that for the purposes of this application the percentages of material are by weight.

In one embodiment, the biaxially stretchable spunbond of the invention demonstrates greater than 25 percent machine and cross-machine direction stretch recovery. In some embodiments which will be described, the material demonstrates soft and silk-like hand. In an alternative embodiment, the cross-directional stretch extends its original length greater than 50 percent. In still a third alternate embodiment, the cross-directional stretch extends greater than 100 percent of its original length. In another embodiment the force required to extend to the 50% of the extension capability level is greater than 100 gms/3inch width, and less than 900 grams/3 inch width. In still another embodiment, the force required to extend to the 50 % of the extension capability level (maximum extension level) is greater than 250 gms/3inch width and less than 750 gms/ 3 inch width. The retraction force is desirably in the same ranges.

Desirably, for a machine direction stretchable material and a machine direction/cross-machine direction stretchable material, the material would demonstrate similar values to those described above for just the cross-machine direction stretch.

Desirably, for each of the materials, the webs demonstrate in the machine-direction (for machine direction stretchable materials only), the cross machine direction (for cross-machine direction stretchable materials only), and the machine and cross-machine direction, greater than 150% extension at break, greater than 25% extensible at a load Ld less than or equal to 900 grams force (gf)/3 inch, but desirably greater than 50 percent extensible at a load Ld less than or equal to 900 gf/3 inch width, and more desirably greater than 100 percent extensible at a load, with the load greater than or equal to 10 and less than or equal to 750 gf. Desirably, the material will demonstrate greater than 1 gf/3 inch width in retraction force at 50% extension on 100 percent first cycle testing and less than 40 percent immediate set at a 50 percent extension, but more desirably less than 30 percent immediate set at a 50 percent extension.

In the invention, certain suitable elastomer and thermoplastic polymers are extruded through a bicomponent spinpack, solidified and cooled to a certain temperature. Typically, in a spunbond process this spin process is followed by a tensioning of the solidified fibers beyond the elastic limit of the thermoplastic polymer, but lower than the ultimate tensile strength of the elastomeric polymer. However, it has been found through the examples, that such spinning and

drawing can be accomplished simultaneously while spinning, as opposed to via a post-spinning operation. The bicomponent fiber structure could be produced in a side-by-side arrangement with circular cross-section, but is more desirably manufactured in a sheath/core arrangement. Such arrangement may be in an eccentric sheath/core arrangement with either a circular or noncircular cross section. Alternatively, the bicomponent fibers may be extruded in a side by side arrangement in a noncircular cross-section, or a concentric sheath/core arrangement with either a circular or non-circular cross section.

Several examples of the webs have been produced. For example, spunbond webs of side-by-side (S/S) bicomponent fibers have been produced from polypropylene and flexible polyolefin. Such material was 100% cross machine and machine direction stretchable. Additionally, eccentric sheath/core fibers were spun using a Kraton G 2755 material as the core and a polypropylene as the sheath. Such materials were highly crimped, as spun, without rubbery hand. Additionally, spunbond fibers were spun into webs from eccentric S/C fibers with the Kraton core and a sheath of polypropylene and linear low density polyethylene. As spun, such materials were fairly extensible and could be made extremely soft to the touch.

In the examples (where Kraton is noted) the core polymer was comprised of Kraton G2755 (which included a wax and a tackifier) or Dow Affinity: single-site catalyzed polyethylene polymer XUS59400.03L (Dow EG 8185). The sheath polymer included polypropylene from Exxon Mobil 3157, Dow Polyethylene Aspun 6811 or a polypropylene/polybutylene 90/10 blend such as Basell Duraflex DP-8510 Polybutylene copolymer. In the examples, the extrusion temperature on both the sheath and the core polymers was approximately 450° F, for the extrusion through the 88 hpi S/C spin pack. The spinplate included a total extrusion rate of 0.6 g/hole/in rate, with 88 holes/in over a 14 inch width.

In the various examples that follow, the ratio of core weight to sheath was varied between 50/50 to 70/30 to 80/20 to 90/10. The fiber draw unit pressure was maintained at 4 psig. Additionally, a compaction roll was utilized for web transfer from the forming wire to the bonder. The webs were bonded on a Ramisch style bond pattern roll or others as noted. The bond temperature of the bond rolls was maintained at between approximately 155 to 165° F. The material was produced at between about 0.5 -2 osy by adjusting wire speed. The following Table 1 describes the physical attributes of the examples materials produced.

Table I

Sample Number	C/S Ratio	Description
1	Kraton/PP 50/50	Smooth fiber surface, very little extensibility
2	Kraton/PP 70/30	Smooth fiber surface; some fiber loop; some MD oriented fibers; soft web
3	Kraton/PP 80/20	Some rippled fiber surface; more and smaller fiber loops and kinks; some crimped fibers; some MD oriented fibers; soft web.
4	Kraton/PP 90/10	Highly rippled fiber surface, even smaller fiber loops and kinks, some crimps; highly MD oriented; very soft and silky hand.
5	Kraton/PE 80/20	Smooth fiber surface, a number of medium size fiber loops; extremely soft by clingy hand.
6	Kraton/(PP/PB1 of 90/10) 70/30	Essentially the same results as Kraton/PP 70/30
7	Kraton/(PP/PB1 of 90/10) 80/20	Essentially the same results as Kraton/PP 80/20
8	Kraton/(PP/PB1 of 90/10) 90/10	Essentially the same results as Kraton/PP 90/10

The following extensibility and retractability data was generated for the above samples.

Table 2 Extensibility of 0.6 osy fabric at 500 gf Load

S/C	Ratio	MD*, %	CD*, %
PP/Kraton	10/90	150	> 400
	20/80	15	100
	30/70		50
PE/Kraton	20/80	>200	350
	30/70		100
(PP/PB1=	10/90	250	>450
90/10)/Kraton	20/80	20	200
	30/70	10	100

Note * the load value was normalized at 0.6 osy

Table 3 CD Tension Set

Sample Number	Core/Sheath Ratio	Tension Set, %		
		10% Ext.	30%Ext.	50%Ext.
3	KR/PP = 80/20	0.10	0.5	26.3
4	KR/PP = 90/10	2.1	3.4	11.7
7	KR/PE = 80/20	3.9	10.6	20.4
19	KR/(PP/PB1=90/10) 80/20	1.9	9.9	25.6
20	KR/(PP/PB1=90/10) 90/10	0	0.7	11.9

Table 4 MD Tension Set

Sample Number	Core/Sheath Ratio	Tension Set, %		
		10%Ext.	30%Ext.	50%Ext.
3	KR/PP = 80/20	0	10.3	27.4
4	KR/PP = 90/10	1.1	6.4	12.5
7	KR/PE = 80/20	2.9	9.7	17.1
19	KR/(PP/PB1=90/10) 80/20	1.2	11.1	23.5
20	KR/(PP/PB1=90/10) 90/10	0.2	4.6	6.9

Retraction Force

Table 5 MD Extension and Retraction Load for 100 % Extension Cycle

Core/Sheath Ratio	1st Cycle Load*, gf/3 in. @ 0.6 osy					
	30%		50 %		75%	
	Ext	Ret	Ext	Ret	Ext	Ret
KR/PP = 80/20	672	0.69	879	0.84	1120	85
KR/PP = 90/10	180	9.5	253	44	346	109
KR/PE = 80/20	136	1.1	174	14	210	63
KR/(PP/PB1= 90/10) 80/20	482	1.0	701	1.8	948	78
KR/(PP/PB1= 90/10) 90/10	62	5.0	97	23	136	58

Note * the load value was normalized at 0.6 osy. The "Ext" represents extension and the "Ret" represents retraction.

The normalized samples in the examples had been prepared at different basis weights. In order to illustrate certain effects on elastic properties more fairly, these property values were normalized at a certain common basis weight using the following equation:

Normalized Property = (measured sample property/sample basis weight) X basis weight to normalize at.

Table 6 CD Extension and Retraction Load for 100 % Extension Cycle

Core/Sheath Ratio	1st Cycle Load*, gf/3 in. @ 0.6 osy Stretching to 100%					
	30%		50 %		75%	
	Ext	Ret	Ext	Ret	Ext	Ret
KR/PP = 80/20	142	2.1	247	1.3	364	23
KR/PP = 90/10	14	1.3	26	4.5	39	15
KR/PE = 80/20	38	1.4	64	3.5	88	21
KR/(PP/PB1= 90/10) 80/20	140	0.6	246	1.8	374	22
KR/(PP/PB1= 90/10) 90/10	18.2	1.7	32	6.8	48	19

Note * the load value was normalized at 0.6 osy

CD Hysteresis and Delayed Recovery

Table 7

Core/Sheath Ratio	% Hysteresis Loss (Energy)			Immed. Set% 6th C. Ret.	Delay. Set% 7th C Ext.	Recov. 1 min %
	1st Cycle	2nd Cycle	3rd Cycle			
KR/PP = 80/20	85.3	57.7	52.6	60.6	46	24.1
KR/PP = 90/10	69.3	50.5	47.8	23.5	11.9	51.4*
KR/PE = 80/20	75.4	56.1	53.3	40.6	19.6	50.4
KR/(PP/PB1=90/10) 80/20	84.6	56.8	52.1	61.7	33.7	45.3
KR/(PP/PB1=90/10) 90/20	60.4	43.8	41.7	25.5	6.3	77.4*

Note * Some repeats for KR/PP, KR/(PP/PB1) = 90/10 exhibits 100 % recovery.

Table 8 MD Hysteresis and Delayed Recovery

Core/Sheath Ratio	% Hysteresis Loss (Energy)			Immed. Set% 6th C. Ret.	Delay. Set% 7th C Ext.	Recov. 1 min %
	1st Cycle	2nd Cycle	3rd Cycle			
KR/PP = 80/20	84.1	61.6	57.1	65.6	16.5	74.9
KR/PP = 90/10	62.8	45.4	43.1	43.4	0	100
KR/PE = 80/20	75	57.7	54.7	55.8	12.8	76.8
KR/(PP/PB1=90/10) 80/20	83.7	58.6	53.6	67.4	0.5	99.3
KR/(PP/PB1=90/10) 90/20	59.4	38.8	38.8	30.64	0	100

Data from such examples may be found reflected in Figures 7 and 8. In particular, Figure 7 is demonstrative of MD hysteresis for Kraton/PP = 90/10, normalized at 0.6 osy. Figure 8 is demonstrative of CD hysteresis for Kraton/PP = 90/10, normalized at 0.6 osy.

The examples indicated that flexural modulus decreases with Core/Sheath ratio with an elastomer core. Flexural modulus decreases with a softer sheath polymer such as PE. Low flexural modulus makes smaller loops, and a large number of kinks during fiber lay-down on the foraminous forming wire to allow such higher "condensation ratio".

More “rigid” fibers such as Kraton/ polypropylene (50/50) spunbond fibers produced big loops, and thus the fiber length per bond spacing is small. On the other hand, the fiber length for the low flexural modulus fibers increases, and thus the softer fiber web is more extensible. The bicomponent softer fibers with elastomer tend to have memory, and thus retract as stress is released. However, the actual fiber length between bond points reaches a maximum value at around Kraton/polypropylene of 70/30, as the retraction force of the stressed elastomer is sufficiently high enough to compress the sheath component, corrugating the fiber surface and increasing the apparent fiber size. Then, fiber pulling takes on a more significant role in the material extension. Such fiber pulling is more important when the fibers are oriented towards the direction of the material extension, as shown in the above MD and CD extension/retraction characteristics. This series of examples are primarily MD oriented. The effect of softer and recoverable sheath, namely polypropylene versus polyethylene, is evident.

For the purposes of determining the fiber length per bond spacing, or fiber length per field width, (FL/FW), an analysis was conducted as previously described. Initially, six samples of webs were tested, including a polypropylene spunbond liner. All six were treated with the

BSE/HICON SEM technique. However, measurements were made only on the Kraton samples because the spunbond web gave a "see-through" effect to the fine fibers and had significantly different and more compact bonding patterns. The methodology employed appeared to demonstrate that 70/30 to 80/20 Kraton/PP gave maximum fiber lengths between bond points. The higher performance MD and CD stretch of the 90/10 blend may be attributed to the thicker fibers which are more stretchable. The resulting data, which is illustrated in the following table, is graphically represented in Fig. 20. The Fig. illustrates the fiber length per bond spacing data for 5 Kraton-series samples, with a maximum function at 70/30 to 80/20 Kraton/PP. The Figure also shows a similar plot based on average fiber diameter. However, the maximum diameter occurs for the 90/10 blend. A series of two BSE/HICON images at 25X are illustrated in FIGs. 3E and 3F. It should be noted that a lower magnification had to be chosen to visualize inter-bond regions. The large morphology differences are clearly evident between the two images, in which in Figure 3E shorter interbond length fibers are seen and in Figure 3F, longer interbond length fibers are seen.

Table 9

Sample	Fib. Diam.(um)	FL/FW *
1 50/50 Kraton/PP	Mean 18.8 S.Dev. 0.481	Mean 33.2 S.Dev. 2.20
2 70/30 Kraton/PP	Mean 18.5 S.Dev. 0.896	Mean 36.1 S. Dev. 2.21
3 80/20 Kraton/PP	Mean 20.3 S. Dev. 0.805	Mean 34.7 S. Dev. 2.45
4 90/10 Kraton/PP	Mean 23.8 S. Dev. 0.847	Mean 28.8 S. Dev. 1.45
5 80/20 Kraton/PE	Mean 22.9 S. Dev. 1.00	Mean 25.2 S. Dev. 1.79

*FL/FW=Fiber length divided by field width, the distance between bond points

The following third set of examples are presented in order to describe the embodiment involving post formation stretching so as to further activate the fibers of the invention. In preparing these examples, a three cycle test was conducted on some of the previously

described samples. These examples have been created in order to demonstrate the effects of prestretching on the MD and CD tensions and immediate % set of the inventive materials at specified extensions.

The materials utilized in the tests were sheath/core bicomponent materials as previously described, including Affinity core/PE sheath; 80/20; 0.6 osy , Kraton core/PE sheath; 80/20; 0.6 osy and Kraton core/PP sheath; 90/10; 1.0 osy. The test method employed in the examples was as follows: Samples were prepared by cutting 3"x 8" samples with the sample length running in the MD direction for samples that were tested for MD tensions and vice versa for samples tested for CD tensions.

The testing apparatus was prepared by utilizing a 50 lbf load cell. As previously described, the operating program consisted of Testworks for windows. It should also be noted that the Gauge Length was 6 inches and the specimen width was 3 inches.

Each specimen was inserted into the Sintech apparatus for 1-Cycle test. The test extension limit was set to the Cycle A limit. The specimen was allowed to complete the cycle. The timer was set for 30 seconds and the test parameters were set to Cycle B extension limits. At the end of the 30 sec. interval, the specimen was allowed to complete Cycle B. After the 2nd Cycle (B), the timer was set for 30 seconds, and the test parameters to Cycle C extension limits were set. The material sample was repositioned so that all slack in the material was removed and the material was taught. The material was then allowed to cycle again at Cycle C extension limits. The data was then exported and recorded. For the test, N=3. The cycle percentages are reflected in the following Table 10.

Table 10

	Cycle A	Cycle B	Cycle C
Affinity/PE	25%	100%	25%
Kraton/PE	50%	200%	50%
Kraton/PP	50%	200%	50%

.

The results of the testing are reflected in Figures 9 to 17 in MD and CD curves. The curves reflect the average of the three repetitions. In particular the curves plot the average of repetitions for each cycle for each material (both MD and CD). Additionally, the data is reflected in load reduction plots, which plot the average extension loads for Cycle A for each

material up to the max. extension limit and plot the average extension loads for Cycle C for each material up to the max. extension limit. In particular, Figure 9 illustrates CD extension and retraction of Kraton/PP; 90/10; 1.0 osy. Figure 10 illustrates the MD extension and retraction of Kraton/PP; 90/10; 1.0 osy. Figure 11 illustrates the CD extension and retraction of Kraton/PE; 80/20; 0.6 osy. Figure 12 illustrates the MD extension and retraction of Kraton/PE; 80/20; 0.6 osy. Figure 13 illustrates the CD extension and retraction cycles for Affinity/PE; 80/20; 0.6 osy. As shown in Figures 14- 15, prestretching is shown to decrease the immediate % set in both the CD and MD for materials tested. Figure 14 illustrates the decrease in CD percent set by prestretching. Figure 15 illustrates the decrease in MD percent set by prestretching. As shown in Figures 16 and 17, prestretching is shown to decrease the percent hysteresis loss in both the CD and MD for materials tested. In particular, Figure 16 illustrates the CD percent hysteresis loss decrease by prestretching. Figure 17 illustrates the MD percent hysteresis loss decrease by prestretching.

The percent set was calculated (the immediate percent set) for the average of Cycles A and C for each material using the following formula:

$$\%Set = \frac{L_f - L_o}{St_f - L_o}$$

where, L_f= final extension length

L_o= initial sample length before extension

St_f= maximum % elongation

The values obtained were then plotted for Cycles A and C for each material.

The improvement in percent set was calculated for the average of Cycles A and C for each material using the following equation:

$$\text{Improvement in \% set} = \left(\frac{\%setCycleA - \%setCycleC}{\%SetCycleA} \right) * 100\%$$

From the testing, it can be seen that the immediate percent set in the machine cross-direction for pre-stretched material ranges from 17% to 35% while that for un-stretched, or control material ranges from 30% to 61%. Therefore, improvements in immediate percent set in the cross-direction of 34% result from prestretching the material. Similarly, in the machine

direction, the immediate percent set of un-stretched material is 24%. After material is stretched, the percent set is reduced to values of 15% to 20%, yielding improvements in immediate percent set in the machine direction of 17% to 38%.

The percent hysteresis loss for each cycle was calculated using the following equation:

$$\% \text{ Hysteresis Loss} = \frac{(\text{area under Extension curve}) - (\text{area under Retraction curve})}{(\text{area under Extension curve})} * 100$$

The area under the curve for each extension (UP) and retraction (DOWN) cycle was calculated by integrating the equation of the best fit line for each curve from lower to upper extension limits. The best fit line was determined as that polynomial which fit the curve with an R^2 value of 0.98 or more. Representative samples of these equations are shown below:

Kraton/PP- CD

Cycle A UP = $\int_0^{50} -0.0081x^2 + 3.6068x + 2.9967 = 4320.835$

Cycle A DOWN = $\int_0^{50} .003x^3 - 0.1395x^2 + 2.2007x - 8.5935 = 1196.2$

The improvement in percent hysteresis loss was calculated for the average of Cycles A, B and C for each material using the following equation:

$$\text{Improvement in \% hysteresis loss} = \left(\frac{\%setCycleA - \%setCycleC}{\%SetCycleA}\right) * 100\%$$

Results from testing show that the percent hysteresis loss in the machine cross-direction for pre-stretched material ranges from 53% to 58% while that for non pre-stretched, or control material (the same material but not prestretched) ranges from 69% to 80%. Therefore, improvements in percent hysteresis loss of 22% to 29% result from prestretching the material. Additionally, in the machine direction, the percent hysteresis loss of non pre-stretched material ranges from 71% to 74%. After material is stretched, the percent hysteresis loss is reduced to 54% yielding improvements in percent hysteresis loss in the machine direction of 23% to 27%.

From the testing, it is apparent that the step of prestretching a material

prior to incorporating such material into a product allows for greater retraction in the product, as opposed to incorporation of the unstretched material into a final product. Such prestretching is particularly effective for lower cost, lower performance elastomers/plastomers.

The effects of bonding pattern on the extension capabilities and abrasion resistance of the inventive material were also investigated. The three bond patterns evaluated were Ramisch, Wire Weave and HDD. Of the three, the Ramisch pattern was the most open with an average bond area of about 11%. The wire weave pattern was of a slightly higher pin density with an average bond area of 18%. The HDD or High Density Diamond pattern yields the tightest bonds with a bond area greater than 25%.

Results indicated that changing from Ramisch to tighter bond patterns increased both the MD and CD extension loads (Tables which follow), while improving the abrasion resistance of Kraton-based materials.

	CD Load (g/3") at % Extension			
Bond Pattern	25%	50%	75%	100%
Ramisch	161	254	313	359
HDD	234	346	425	481

Effects of Bond Pattern on CD Extension of Kraton/PE=80/20

	MD Load (g/3") at % Extension			
Bond Pattern	25%	50%	75%	100%
Ramisch	473	614	689	735
HDD	696	896	1020	1115

Effects of Bond Pattern on MD Extension of Kraton/PE=80/20

Although various embodiments of the invention have been described using specific terms, devices, and methods, such description is for illustrative purposes only. The words are words of description rather than of limitation. It is to be understood that changes and variations may be made by those of ordinary skill in the art without departing from the spirit or scope of the present invention, which is set forth in the following claims. In addition, it should be understood that aspects of the various embodiments may be interchanged both in whole or in part. Therefore, the spirit and scope of the appended claims should not be limited to the description of the preferred versions contained therein.